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New Camera Mimics Design of Human Eye

By Steve Bosak
August 7, 2008 2:46PM

A camera based on the biological design of the human eye has been developed by researchers at the University of Illinois at Urbana-Champaign and Northwestern University. Prof. John Rogers said his team has overcome the challenge of placing sensors in elastic material without breaking electronic connections.

Researchers at the University of Illinois at Urbana-Champaign and Northwestern University have announced the development of a camera based on the biological design of the human eye. While it won't make a 10-megapixel digital camera obsolete, it may be a huge breakthrough in bioengineering.

U of I Prof. John Rogers, the team's head researcher, said, "This approach allows us to put electronics in places where we couldn't before." Researchers at Northwestern University and other academic institutions helped in the design and fabrication processes.

Artificial Sight

The development could herald an era of artificial sight. Current optical technology relies on rigid-surface, fixed electronics. While this is more than serviceable in a camera, human eyes must pivot, scan and collect a wide view of information with a flexible retina.

Such a natural design requires flexible components and nonrigid properties previously impossible to engineer. The challenge for researchers hinged on embedding light and image sensors in elastic material without breaking electronic connections or distorting images. It appears the discovery by Rogers and his team has succeeded.

To implant the electronics, the researchers first developed a rubber membrane in the hemispheric shape of an eye. The membrane was then stretched to form a drumhead. A prefabricated array of sensors embedded in silicon was then transferred using planar processing -- much like current chip manufacturing. When the membrane comes off the drumhead, it returns to its original shape and compresses the embedded focal array.

The key point is that specially designed interconnects delaminate from the membrane yet maintain contact with detector pixels. The array is then transfer-printed to a glass substrate identical to the original shape. The artificial retina is then attached to an external connection and a lens is set

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Resolution Factor

The result is the world's first imaging device modeled on the eye. The resolution of the device is just 256 pixels -- but according to Rogers, this is not as low as it may sound.

"By using biologically inspired imaging modes, in which the electronic eye rotates through small angles and the computer synthesizes a sequence of images, we achieve much higher levels of effective resolution," he said. "The small number of pixels is limited only by our university clean-room fabrication facilities. Theoretical analysis by our collaborators at Northwestern confirm the compatibility of the basic approaches with much higher numbers of detector pixels."

The implications for research into retina replacement are huge. The U of I device is based on a natural eye design, including the focal point of the lens. "Hemispherical detector arrays are also much better suited for use as retinal implants than flat detectors," Rogers said. "The ability to wrap high-quality silicon devices onto complex surfaces and biological tissues adds very interesting and powerful capabilities to electronic and optoelectronic device design."

Asked if the work is directly applicable to biomedical research, Rogers said, "In our present fabrication sequence, the thin elastomer drumhead is used only as an element to accomplish the planar-to-hemispherical geometry transformation. The final substrate is glass. One could, conceivably, use the elastomer itself as the substrate. Such an approach would, clearly, enhance the biocompatibility by matching the mechanical properties of the artificial retina to the actual retina. That's a concept for future work.

The ability to hook into human tissue -- the brain, for example -- is a great leap forward in complexity. Just a few years ago, naysayers were still arguing that an artificial camera based on the eye's design was too difficult to build.

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